

What is Claimed is:

- [c1] A process for recovering naturally occurring nanoclusters, comprising: providing an aqueous nanocluster slurry from a nanocluster bearing source material comprising naturally occurring nanoclusters and a host substrate; and desorbing and isolating said naturally occurring nanoclusters from said host substrate.
- [c2] The process claimed in claim 1 where the naturally occurring nanoclusters occur adsorbed to a host substrate.
- [c3] The process claimed in claim 1 where the naturally occurring nanoclusters occur as nanocluster colloids.
- [c4] The process claimed in claim 1 where the naturally occurring nanoclusters occur as nanocluster gels..
- [c5] The process claimed in claim 1 where the naturally occurring nanoclusters occur as mixtures of two or more members selected from the group consisting of nanoclusters, nanocluster colloids and nanocluster gels.
- [c6] The process claimed in claim 1 where the nanocluster bearing source material is a solid.
- [c7] The process claimed in claim 1 where the nanocluster bearing source material is a liquid.
- [c8] The process claimed in claim 1 where the nanocluster bearing source material is a gas.
- [c9] The process claimed in claim 1 where the nanocluster bearing source material is two or more members selected from the group consisting of solid, liquid and gas nanocluster bearing source materials, in any proportion thereof.
- [c10] The process claimed in claim 1 where the naturally occurring nanoclusters comprise one or more elements selected from the group consisting of Li, Na, K, Rb, Cs and Fr, in combination with any other elements.
- [c11] The process claimed in claim 1 where the naturally occurring nanoclusters comprise one or more elements selected from the group consisting of Be, Mg, Ca, Sr, Ba and Ra, in combination with any other elements.
- [c12] The process claimed in claim 1 where the naturally occurring nanoclusters comprise one or more metals selected from the group consisting of Au, Ag, Ru, Os, Rh, Ir, Pd and Pt, in combination with any other elements.
- [c13] The process claimed in claim 1 where the naturally occurring nanoclusters comprise one or more non-precious transition metal elements selected from the group consisting of Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mn, Tc, Re, Fe, Co, Ni, Cu, Zn, Cd and Hg, in combination with any other elements.
- [c14] The process claimed in claim 1 where the naturally occurring nanoclusters comprise one or more metals or metalloid elements selected from the group consisting of B, Al, Ga, In, Tl, Si, Ge, Sn, Pb, As, Sb, Bi, Te and Po, in combination with any other elements.
- [c15] The process claimed in claim 1 where the naturally occurring nanoclusters comprise one or more non-metallic elements selected from the group consisting of C, N, P, O, S and Se, in combination with any other elements.
- [c16] The process claimed in claim 1 where the naturally occurring nanoclusters comprise one or more halogen elements selected from the group consisting of F, Cl, Br, I and At, in combination with any other elements.

- [c17] The process claimed in claim 1 where the naturally occurring nanoclusters comprise one or more rare earth elements selected from the group consisting of La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Ac, Th, Pa, U and Pu, in combination with any other elements.
- [c18] The process claimed in claim 1 where the nanocluster bearing source material is prevented from drying by isolation from atmosphere, by addition of water, or by a combination thereof.
- [c19] The process claimed in claim 1 where the nanocluster bearing source material is an aqueous nanocluster bearing source material.
- [c20] The process claimed in claim 19, further comprising, after the desorbing step, recovering nanocluster colloids to form a nanocluster concentrate.
- [c21] The process claimed in claim 20, wherein said recovering step is performed by one or more processes selected from the group consisting of gravity settling, adsorption, ion exchange, heating, coagulation, flocculation, filtration, centrifugation, electrolysis, and dialysis.
- [c22] The process claimed in claim 20, where the desorbing step is performed by addition of one or more reagents to cause nanoclusters to be desorbed from the host substrate said reagents being selected from the group consisting of alkali and ammonium hydroxides, inorganic acids selected from the group consisting of hydrochloric, nitric and sulphuric acids, and organic acids.
- [c23] The process claimed in claim 1, wherein said isolating step comprises: separating and recovering an aqueous nanocluster colloid solution formed by the desorbing step, by one or more processes selected from the group consisting of gravity settling, centrifugation and filtration to form a separated aqueous nanocluster colloid solution; and treating the separated aqueous nanocluster colloid solution by one or more processes selected from the group consisting of gravity settling, adsorption, ion exchange, coagulation, flocculation, filtration, centrifugation, heating, electrolysis, and dialysis to produce a nanocluster concentrate.
- [c24] The process claimed in claim 23 wherein the nanocluster bearing source material is a solid nanocluster bearing source material and the aqueous nanocluster slurry is provided by: reducing the solid nanocluster bearing source material particle size by crushing; mixing the crushed solid nanocluster bearing source material with water to form a slurry; wet milling the slurry to provide a particle size of the solid nanocluster bearing source material of 100 mesh or smaller.
- [c25] The process as claimed in claim 24, wherein said particle size of the solid nanocluster bearing source material is 80 % of particles of 250 mesh or smaller.
- [c26] The process claimed in claim 24 where the crushed solid nanocluster bearing source material is dry milled prior to mixing with water.
- [c27] The process claimed in claim 24 wherein one or more gel hydration reagents selected from the group consisting of hydrochloric and nitric acids, organic acids and alkali bases and salts are added to the slurry prior to wet milling.

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- [c28] The process claimed in claim 23, wherein the nanocluster bearing source material is an organic liquid nanocluster bearing source material and said aqueous nanocluster slurry is provided by: separating any water contained in the organic liquid nanocluster bearing source material by one or more processes selected from the group consisting of gravity settling, centrifugation and application of surfactants, heat and steam; separating nanocluster-bearing material from organic liquid by one or more processes selected from the group consisting of addition of a soluble organic solvent to reduce viscosity, gravity settling, filtration, centrifugation, heating and surfactant addition; mixing the separated nanocluster bearing material with water to form an aqueous nanocluster slurry.
- [c29] The process claimed in claim 23, wherein the nanocluster bearing source material is a gaseous nanocluster bearing source material, and said aqueous nanocluster slurry is provided by passing the gaseous nanocluster bearing source material through a condenser and one or more scrubbers such that the nanoclusters are collected in an aqueous scrubber solution.
- [c30] The process claimed in claim 29, wherein said aqueous scrubber solution is an acidic solution made acidic by the addition of 0.1 to 1 % hydrochloric acid, sulphuric acid or aqua regia.
- [c31] The process claimed in claim 30, wherein said aqueous scrubber solution is a reducing solution made reducing by addition of 0.1 to 1 % alkali sulphide or borohydride in a 1 to 5 % alkali hydroxide basic solution.
- [c32] The process claimed in claim 1 where the nanocluster bearing source material is a mixture of a liquid nanocluster bearing source material and one or more nanocluster bearing source materials selected from the group of solid and gas nanocluster bearing source materials.
- [c33] The process claimed in claim 32 where the nanocluster bearing source material is a mixed nanocluster bearing source material, which is separated into solid, liquid and/or gas nanocluster bearing source materials and each of the resulting solid, liquid or gaseous nanocluster bearing source materials are processed separately.
- [c34] The process claimed in claim 23 where the aqueous nanocluster slurry is conditioned prior to the desorbing step by addition of one or more members selected from the group consisting of aqueous inorganic acid solutions, caustic reagents, chemical oxidizing reagents and combinations thereof.
- [c35] The process claimed in claim 23, wherein the aqueous nanocluster slurry is conditioned prior to the desorbing step by addition of one or more of: a) an aqueous inorganic acid solution selected from the group consisting of hydrochloric acid, nitric acid, sulfuric acid and mixtures thereof; b) caustic reagents selected from the group consisting of alkali and ammonium hydroxides and mixtures thereof; or c) chemical oxidizing reagents selected from the group consisting of alkali hypochlorites, peroxides and ozone.
- [c36] The process claimed in claim 35 wherein slurry solids containing the nanocluster bearing source materials are separated and recovered from the conditioned aqueous slurry by addition of a coagulant or flocculant and/or heat treatment in order to settle out the slurry solids, which are subsequently recovered by filtration or centrifugation and then mixed with water to reform the aqueous nanocluster slurry.

- [c37] The process claimed in claim 23 wherein nanocluster gels contained in the nanocluster bearing source material and aqueous slurry are rehydrated by addition of one or more acids selected from the group consisting of inorganic acids and organic acids.
- [c38] The process claimed in claim 37, wherein the one or more acids are selected from the group consisting of hydrochloric acid, nitric acid, acetic acid and humic acid.
- [c39] The process claimed in claim 23, wherein one or more alkali bases, salts or mixtures thereof added to the aqueous nanocluster slurry to peptize nanoclusters present therein, thereby regenerating nanocluster colloids.
- [c40] The process claimed in claim 23 wherein the aqueous nanocluster slurry is treated by a combination of elevated temperature and/or elevated pressure, and agitation to effect gel hydration and nanocluster peptization.
- [c41] The process claimed in claim 23 wherein one or more dispersants are added to the aqueous nanocluster slurry to promote dispersion of host substrate.
- [c42] The process claimed in claim 41, wherein said one or more dispersants are selected from the group consisting of ammonium and alkali hydroxides, polyphosphates, silicates, carbonates and polyelectrolytes.
- [c43] The process claimed in claim 1, wherein the desorbing step is performed by addition of acids or bases to modify pH of the aqueous nanocluster slurry in such a manner that the nanoclusters are desorbed from the host substrate and enter into aqueous solution as nanocluster colloids.
- [c44] The process claimed in claim 23 wherein one or more members selected from the group consisting of alkali and ammonium salts of chlorides, sulphates, thiosulphates, and peroxydisulphates, are added to the aqueous nanocluster colloid slurry to promote stabilization of the nanocluster colloids.
- [c45] The process claimed in claim 23, wherein the treating step is by adsorption using a sorbent of activated carbon.
- [c46] The process claimed in claim 23 wherein the treating step is by ion exchange using an ion exchange resin.
- [c47] The process claimed in claim 23 wherein the treating step is by passing the nanocluster colloid solution through a column loaded with a sorbent or ion exchange resin to provide isolated nanocluster colloids on said column.
- [c48] The process claimed in claim 23 where the nanocluster colloids are recovered by contacting the aqueous nanocluster slurry with sorbents or ion exchange resins prior to decanting depleted host substrate and source material residue.
- [c49] The process claimed in claim 1 where the nanoclusters are further processed to recover macrocrystalline solids.
- [c50] The process claimed in claim 23, wherein the nanocluster concentrate is further processed to recover macrocrystalline solids.
- [c51] The process claimed in claim 50 where the nanocluster concentrate is dissolved by one or more inorganic acids selected from the group consisting of hydrochloric acid, nitric acid, and sulfuric acid, and recovered by any combination of sorption, ion exchange, precipitation, electrowinning or cementation.

- [c52] The process claimed in claim 50 where the nanocluster concentrate is treated with an oxidizing agent selected from the group consisting of alkali peroxides, nitrates, chlorates, perchlorates and persulphates, their respective acids, and ozone.
- [c53] The process claimed in claim 50 where the nanocluster concentrate is treated with a reducing agent selected from the group consisting of alkali borohydrates, alkali sulphides, and organic acids.
- [c54] The process claimed in claim 50 wherein the nanocluster concentrate is subjected to a combination of heat and pressure treatment under controlled atmosphere conditions to produce a macrocrystalline solid.
- [c55] The process claimed in claim 54 wherein the controlled atmosphere conditions are an oxidizing atmosphere obtained by introduction of one or more oxidizing gases.
- [c56] The process claimed in claim 55 wherein the one or more oxidizing gases are selected from the group consisting of oxygen, sulfur dioxide, and nitrous oxide.
- [c57] The process claimed in claim 54 wherein the controlled atmosphere conditions are a reducing atmosphere obtained by introduction of one or more reducing gases.
- [c58] The process claimed in claim 57, wherein the one or more reducing gases are selected from the group consisting of hydrogen, hydrogen sulfide and hydrocarbon gases.
- [c59] The process claimed in claim 55 further comprising addition of one or more fluxing reagents or collectors or both.
- [c60] An isolated naturally occurring nanocluster..
- [c61] An isolated naturally occurring nanocluster obtained by the method of claim 1.
- [c62] The isolated naturally occurring nanocluster of claim 60, comprising one or more metals selected from the group consisting of Au, Ag and platinum group metals.
- [c63] The isolated naturally occurring nanocluster of claim 60, comprising Cu and one or more other metals.
- [c64] The isolated naturally occurring nanocluster of claim 63, wherein the one or more other metals are selected from the group consisting of Au, Ag and platinum group metals.

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